An adjuvant is broadly defined as any nonpesticide material added to a pesticide product or pesticide spray mixture to improve the pesticide's performance and/or alter the physical properties of the spray mixture. Examples of adjuvants include surfactants, oils, compatibility agents, buffering and conditioning agents, defoaming agents, deposition agents, drift control agents, and thickeners.

The proper adjuvant may reduce or even eliminate spray application problems, thereby improving overall pesticide effectiveness. Because adjuvants themselves have no pesticidal properties, they are not required to be registered by the U.S. Environmental Protection Agency (EPA). Also, most states, including Pennsylvania, do not regulate the distribution of adjuvants.

However, quality adjuvants can be identified several ways. The Council of Producers and Distributors of Agrotechnology (CPDA), an organization of inert ingredient and adjuvant manufacturers, certifies adjuvants by developing minimum standards that must be met in order to receive the CPDA stamp of certification. ASTM International (previously known as the American Society for Testing and Materials) is an international standards organization that develops and publishes voluntary consensus technical standards. They have a standard that defines the various claims that an adjuvant label may include and reference the methods by which the claim can be proved.

Adjuvants and Spray Application

Adjuvants are designed to perform specific functions, including buffering, dispersing, emulsifying, spreading, sticking, and wetting. Adjuvants also can reduce evaporation, foaming, spray drift, and volatilization. No single adjuvant can perform all these functions, but different compatible adjuvants often can be combined to perform multiple functions at the same time. Therefore, using adjuvants may not only help minimize spray application problems but also boost the pesticide's effectiveness.

The spray adjuvants can be categorized into two groups: activator adjuvants and special-purpose or utility adjuvants.

Activator Adjuvants

The main purpose of activator adjuvants is to improve the “activity” of the pesticide product. These improvements—both physical and chemical—generally lead to better absorption and, as a result, a more efficient use of the pesticide. Activator adjuvants include surfactants, oils, and nitrogen-based fertilizers.

Surfactants

Surfactants (surface active agents), also called wetting agents and spreaders, physically change the surface tension of a spray droplet. For a pesticide to perform its function properly on a plant, the spray droplet must be able to wet the foliage and spread out evenly. Surfactants make the area of pesticide coverage larger, which increases the pest’s exposure to the chemical (see Figure 1). Surfactants are particularly useful when applying a pesticide to a plant with waxy or hairy leaves. Without proper wetting and spreading, spray droplets often run off or fail to provide good coverage to the surfaces. Too much surfactant, however, can cause excessive runoff, which may make the pesticide less effective.
Classification of Surfactants

Surfactants are classified by the way they ionize, or split apart, into electronically charged molecules called ions. Use only the type as directed on the label.

**Anionic Surfactants** *(negative charge)*
- Most effective when used with contact pesticides

**Cationic Surfactants** *(positive charge)*
- Should never be used as stand-alone surfactant because they are usually phytotoxic (poisonous to plants)

**Nonionic Surfactants** *(no charge)*
- Composed of alcohols and/or fatty acids and are compatible with most pesticides
- Pesticidal activity can be quite different from that of anionic or cationic surfactants
- Helps pesticide sprays penetrate plant cuticles
- Often used with systemic pesticides
- Most registered pesticides that require using a surfactant recommend this type

**Organo-silicone Surfactants** *(a newer group taking the place of nonionic surfactants)*
- Reduces surface tension, increases spreading ability, and improves rainfastness (amount of time between pesticide application and rainfall)

Keep in mind that selecting the wrong surfactant can reduce the effectiveness of a pesticide product and increase the risk of plant injury.

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**Oils**

Oils are being used to control grassy weeds. The three types of oil-based adjuvants include crop oils, crop oil concentrates, and vegetable oil concentrates.

**Crop oil** is generally 95 to 98 percent paraffin or naptha-based petroleum oil with 1 to 2 percent surfactant/emulsifier. Crop oils promote the penetration of a pesticide spray either through a plant’s waxy cuticle or through an insect’s tough, chitinous shell. Traditional crop oils are more commonly used for insect and disease control and rarely with herbicides.

**Crop oil concentrates (COCs)** are made up of 80 to 85 percent emulsifiable petroleum-based oil and 15 to 20 percent nonionic surfactant. Crop oil concentrates have the penetration properties of oil and the spreading properties of a surfactant. COCs are often used with postemergence herbicides.

**Vegetable oil concentrates (VOCs)** are made up of 80 to 85 percent crop derived seed oil (usually cotton, linseed, soybean, or sunflower oil) and 15 to 20 percent nonionic surfactant. To improve their performance, many VOCs have undergone a process called esterification, which increases the oil-loving characteristics of the seed oil and results in a methylated seed oil (MSO). MSOs work the same as traditional crop oil concentrates to increase penetration of the pesticide into the target pest.

**Nitrogen-based Fertilizers**

Improved herbicide activity has been shown by adding ammonium sulfate or urea-ammonium nitrate to the spray mixture. Nitrogen fertilizers may replace some adjuvants but are usually included in addition to a surfactant and a crop oil concentrate for use with systemic pesticide products. Many fertilizer-based adjuvants are available in liquid forms, which are easier to mix and provide more consistent results. Fertilizers should only be used with herbicides when recommended by the label.

**Special Purpose/Utility Adjuvants**

Special purpose adjuvants fix specific conditions that can affect the spray solution or the actual application of the pesticide in a negative way. By controlling these factors, you can maximize the efficient use of the pesticide. Compatibility agents, buffering and conditioning agents, defoaming agents, deposition agents (stickers), and drift control agents and thickeners modify the physical characteristics of the spray solution. Foam markers, tank cleaners, colorants, and suspension agents help minimize application problems. Carefully follow product label directions before adding any adjuvant to a spray mix.

**Compatibility Agents**

Pesticides are commonly mixed with liquid fertilizers or other pesticides. However, some combinations can be physically or chemically incompatible, causing clumps and uneven distribution in the spray tank. Occasionally, the incompatible mixture will clog the pump and hoses, resulting in expensive cleanup and repairs. Using a compatibility agent may eliminate these problems. A “jar test” can help determine the stability of the mixture (see panel).
Buffering and Conditioning Agents
Most herbicides, insecticides, and fungicides perform best in slightly acidic water with a pH of 4.0 to 6.5 with the exception of sulfonylurea herbicides, which perform better in water with a pH of 7.0 or above. Pesticide solutions above pH 7.0 are at greater risk of degrading or breaking down. In some cases, a pesticide that is stable when the water pH is 5.0 will lose half its effectiveness in as little as 15 minutes if the pH of the water is 9.0. Acidifier adjuvants lower the pH of the water in the spray tank, although they do not necessarily maintain a constant pH level. Buffers tend to stabilize the pH at a relatively constant level.

Conditioning or water-softening agents reduce problems caused by hard water. Hard water minerals, especially calcium and magnesium ions, bind with active ingredients of some pesticides, which may decrease pesticide performance. Before using a buffer or conditioning agent, consider the specific pesticide requirements and test the water for pH and hardness. Also refer to the pesticide label for precautions and recommendations.

Defoaming Agents
Some pesticide formulations create foam or a frothy head in some spray tanks. This is often the result of the type of surfactant used in the formulation and the type of spray tank agitation system. The foam usually can be reduced or eliminated by adding a small amount of a defoaming agent.

Deposition Agents
These adjuvants, which are often referred to as “stickers,” increase the ability of solid particles to stick to the target surface. These adjuvants can decrease the amount of pesticide that washes off during irrigation or rain. Deposition agents can also reduce evaporation of the pesticide and some can slow degradation of pesticides by ultraviolet rays. Many deposition agents also include a wetting agent to make a general purpose product that both spreads and sticks to the target surface.

Drift Control Agents and Thickeners
Drift is a function of droplet size, wind speed, and height of the spray boom. Small droplets (with diameters of 150 microns or less) tend to drift away from targeted areas. Drift retardants or deposition aids improve on-target placement of the pesticide spray by increasing the average droplet size. Drift reduction is a priority near sensitive sites or when conditions warrant extra precaution. Using a spray drift agent may be well worth the small reduction in the effectiveness of the application that can result from the change in droplet size.

Thickeners, as the name suggests, increase the viscosity of spray mixtures. These adjuvants are used to control drift or slow evaporation after the spray has been deposited on the target area. Slow-
Tank Cleaners
Commercial tank cleaners are designed to work with water and oil soluble pesticide products and are often recommended on pesticide labels. Always refer to the label for recommended tank cleaners with the product being used. Always follow label directions and wear personal protective equipment when cleaning a sprayer.

Colorants
Colorants are used to alter the color of spray solutions to visually aid in the placement of the spray solution.

Suspension Agents
These products extend the amount of time a pesticide will remain in suspension. If agitation is stopped for a time, upon restarting the agitation, this product aids in resuspending the mixture.

How to Choose the Right Adjuvant
Many factors must be considered when choosing an adjuvant for use in a pest management program. The following are some guidelines:

- First and foremost, read the pesticide label.
- Use only adjuvants manufactured and marketed for agricultural or horticultural uses. Do not use industrial products or household detergents with pesticides because they may interfere with or reduce pesticide performance.
- Pesticide labels seldom mention specific brands of adjuvants, but rather the general type of adjuvant, such as non-ionic surfactant, crop oil, or defoaming agent. However, if the pesticide label lists a specific brand of adjuvant, that brand must be used. Any substitution would be a violation of the label.
- Miracle adjuvants do not exist. Ignore claims such as “keeps spray equipment clean,” or “causes better root penetration.” Always buy recognizable, name-brand products from a reputable dealer.
- Adjuvant recommendations may change due to changes in pesticide formulations, newly labeled tank mixes and premixes, and changes in application technology and procedures. Always read the label every time a pesticide product is used.

- Using an adjuvant is not always necessary. Knowing when not to use an adjuvant is just as important as knowing when to use one. If the pesticide label does not mention an adjuvant, the manufacturer’s research probably has shown no benefits—or even adverse effects—from adjuvant use.

Spray adjuvants can play a major role in safe and effective pest control when used as recommended on the label. Although a single adjuvant may perform more than one function, no single product can solve every problem. As a result, many spray adjuvants are available, each formulated to solve problems associated with a particular type of application. Read the pesticide label.

The correct use of adjuvants does require knowledge of the site you plan to spray, the target pest, your equipment, and, of course, the pesticide you plan to use. By knowing the particular needs and limitations of the products you intend to use, adjuvants can prove to be a positive addition to the spray tank.

References

Petroff, Reeves. “Pesticide Adjuvants and Surfactants” and “Pesticide Interactions and Compatibility,” Montana State University.


Poison Control Centers
1-800-222-1222
Calling the toll-free National Poison Center hotline above will connect you to the nearest poison center. Pennsylvania residents are served by the Pittsburgh Poison Center and the Poison Control Center in Philadelphia.

Pesticide Safety Fact Sheets
Pesticide Safety Fact Sheets are produced by the Pesticide Education Program in Penn State's College of Agricultural Sciences. Topics covered in the series include:

- Pesticide storage and security
- Handling chemical spills
- Personal protective gear
- Spray adjuvants
- Pesticide toxicity and health effects
- EPA Worker Protection Standard
For a complete list of fact sheets and electronic copies or for more information about the Pesticide Education Program, please visit extension.psu.edu/pested on the web.

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